<Session 5: Wildlife Tracking I>Development of Ultra-Compact Bird-Borne S-band Transceiver for Wild Birds

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A Development of Ultra-Compact Bird-Borne S-band Transceiver for Wild Birds

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Abstract

The necessity of monitoring of the wilds birds across the border by using ICT is already confirmed in International Telecommunication Union (ITU). We developed a ultra-compact bird-borne S-band transceiver, which the biological information and the positional information of the birds can be obtained by using the bird-to-bird communications and the bird-to-centre communications. This transceiver is composed of Texas Instrument Inc.CC2500 packet communication device and can choose a transmission speed from 1200bps to 500kbps, and can choose a modulation from 2FSK, GFSK, MSK, OOK. We sought the optimal parameter for both communications by using the evaluation experiment.

***Keywords**: S-band transceiver, OOK modulation, Packet communication, Monitoring of wild birds, CC2500*

1 Objective

The bird-borne S-band transceiver is composed of Texas Instrument Inc. CC2500 for packet communication. This device can choose a modulation-technique from 2FSK, GFSK, MSK, OOK. The objective of this paper is to seek the optimal parameter of the bird-to-bird communications and the bird-to-centre communications by using the evaluation experiment.

2 Background

The necessity of monitoring of the wild birds across the border by using ICT is already confirmed in International Telecommunication Union (ITU) [1]. In the past, the wilds birds were tracked by the ARGOS system, which used NOAA satellite. However, the measured position accuracy wasn't so high and there was a limit in the memory capacity for the measured data [2]. Therefore, by attaching the transceiver to the wild birds, we have started the research to get the biological information and the positional information by using the bird-to bird communications and the bird-to-centre communications [2].

3 Design of transceiver

3.1 Request performance

We designed a database and implemented a RBBS (Radio Bulletin Board System). We entered the corresponding biological and positional information and data for each device as files into a database, with each filename based on a unique identification number and date. For bird-to-bird communication, the autonomous decentralized RBBS first exchanged data between files, then collected files possessed by one bird, but not others. First installed in the PAX-88B packet radio communication modem by Escuela Inc. (Yokohama) in 1988, this RBBS function has been used successfully in the area of radio communications.

Because the CPU mounted on the transceiver manages the network topology and the file on RBBS concurrently, two communication-transfer-rates and two communication distance (the expectation value) are assumed. Table 1 shows the request performance of the bird-to-bird communications and the bird-to-centre communications.

Table 1: Request Performance

Communication Type	Distance	Communication Rate (kbps)	Message
Bird-to-Bird Communications	200m	250-500	File Transfer
Bird-to-Centre Communications	18km	2.4	ID Recognition

3.2 Overview of packet communication device (CC2500)

CC2500 is the low power consumption type packet receiver-transmitter of S-band (2.4GHz), which can be transmitted at line speed of 1.2-

500kbps. FIFO (First In, First Out), which is memory for the packet, is very small of 64 bytes, but can handle a big packet with interrupt. 2FSK, GFSK, MSK, OOK can be chosen as the modulation-technique, and either of FEC (Forward Error Correction) and Manchester coding of the modulation part can be chosen as the error correction. A conceptual block diagram is shown in Figure 1.

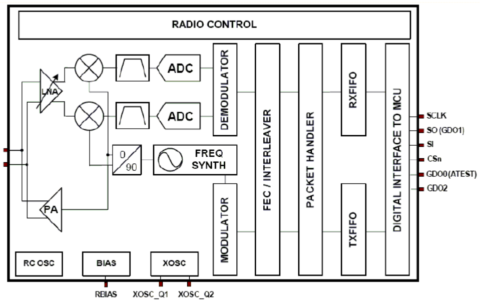


Fig.1: Conceptual block diagram of CC2500

3.3 Communication line design

The error rate of the packet communication device CC2500 becomes equal to or less than 5 % at -135dBW when the modulation is 2FSK, the frequency shift is 14.28 kHz, the line speed is 2.4kbps, Manchester coding is ON and the received IF bandwidth is 101.56 kHz. The error rate of the packet communication device becomes equal to or less than 5 % at -116dBW, when the modulation is MSK, the line speed is 500bps, FEC is ON, and the received IF bandwidth is 812.5khz

Each communication line was designed based on above mentioned values. As a result, as shown in Table 2, the maximum distance of the bird-to-bird communications becomes 400 m and the maximum distance of the bird-to-centre communications becomes 35 km. These results meet 200 m and 18 km of the request performance shown in Table 1.

Table 2: Communication line design

ITEM	UNIT	Bird-to-Bird Communications	Bird-to-Centre Communications
Ditance	(Km)	0.4	35
Frequency	(GHz)	2.43	2.43
Trasmit Antenna Gain	(dB)	3	3
Transmiter Power	(dBW)	-30	-30
EIRP	(dBW)	-27	-27
Free Space Propagation Loss	(dB)	92.2	131.04
Atomospheric Absorption	(dB)	0	0
Receive Antenna Gain	(dB)	3	23
Received Sigal Power	(dBW)	-116.2	-135.04
Noise Temperature	(K)	600	600
Noise Power Density	(dBW/Hz)	-200.82	-200.82
G/T	(dB/K)	-24.78	-4.78
Uplink C/No	(dB Hz)	84.62	65.78
500kbps Detection Limit	(dBW)	-116.33	-135.15

4 Experiment

4. Fabrication of transceiver

Figure 2 shows the block diagram of the fabricated ultra-compact bird-borne S-band transceiver. The transceiver is composed of RF antenna, packet communication device (CC2500), CPU, RAM, ROM, GPS, the solar cell for the power, and the rechargeable battery

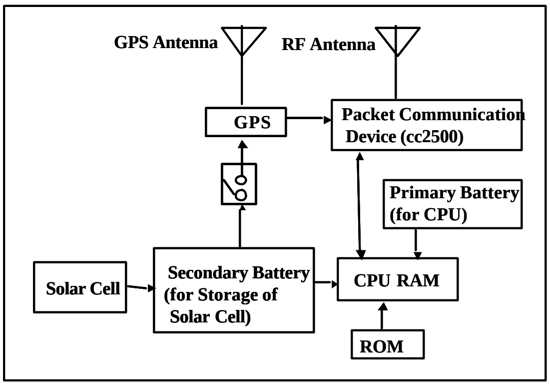
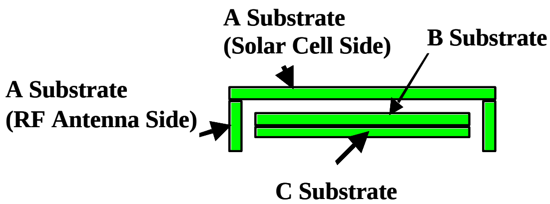
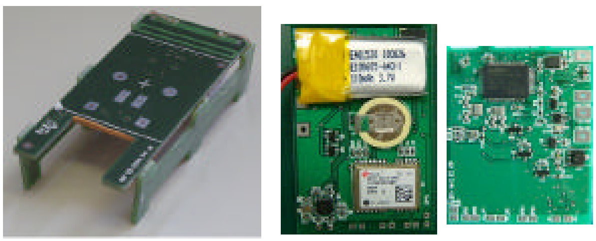


Fig.2: Block diagram of transceiver

The transceiver is composed of A substrate, B substrate and C substrate as shown in Figure 3. RF antenna and the solar cell are mounted on A substrate (Fig.3 (b)), the packet communication device and the GPS are mounted on B substrate (Fig.3 (c)) and RAM, ROM and CPU are mounted on C substrate (Fig.3 (d)). These substrates of the transceiver are composed like Fig.3 (a). The weight is about 20g.



(a) Combination of each substrate



(b) A Substrate (c) B Substrate (d) C Substrate

Fig.3: Configuration of transceiver

4.2 Experimental evaluation

(1) Evaluation system

The performance of the transceiver was evaluated using the evaluation system shown in Figure 4. The evaluation system is composed of an evaluation-board, a control PC and an attenuator.

The evaluation-board is composed of the packet communication device CC2500 and the transmitter-receiver. The attenuator is used for modelling of the space propagation loss.

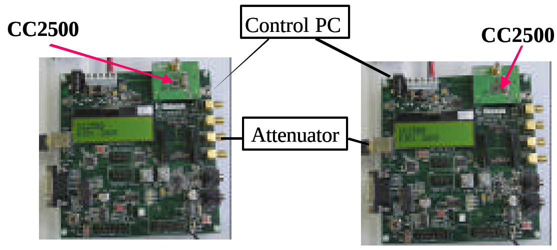


Fig.4: Evaluation system of transceiver

(2) OOK modulation

OOK modulation (On-Off Keying) is one of the amplitude modulation. "There is a carrier" is 1 and " there is not carrier" is 0. In this way, OOK is a coded signal. The telegraph, which used Morse code, is one kind of OOK. It was the modulation, which is hardly used before.

However, recently, it is applied to ADS-B (Automatic Dependent Surveillance Broadcast), ETC (Electronic Toll Collection System), the RFID tag and so on. Because of amplitude modulation, it is possible to take the synchronization of the signal easily in OOK.

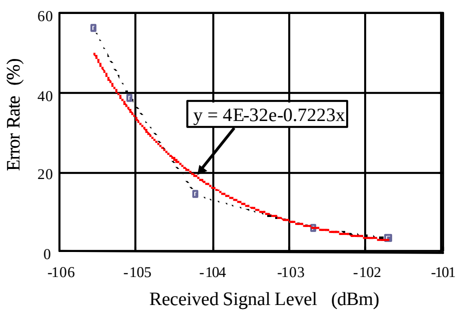


Fig.5 Eerror rate of OOK modulation

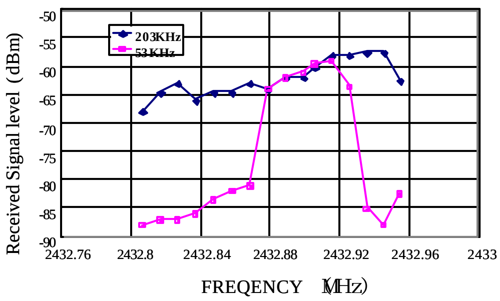


Fig. 6 Spectrum of RSSI

Figure 5 shows an error rate of the OOK modulation to the received signal level. It is possible to understand that from the measured data the error rate is increasing like an exponential function to the received signal level. The range to 20 % of error rates in -105 dBm of 1 received-signal-level seems to be practical. Figure 6 shows the spectrum of RSSI (Received signal strength indicator). In the 2FSK modulation, the bandwidth is wide 104 kHz. However, C/N in the OOK modulation is estimated to be improved by 3 dB because the bandwidth is suppressed to about half.

5 Consideration

From former evaluation experiment, the best modulation to the comparatively long distance bird-to-centre communications was 2FSK modulation of 14.28 kHz of frequency shift and 101.56 kHz of received IF signal bandwidth. This is when a centre frequency is controlled by effectively operated AFC. It was clear that OOK could improve C/N compared with 2FSK by the experiment this time. Also, the way of seeking a centre frequency by the spectrum analysis on the time axis as the substitution of AFC is valid.

6 Conclusion

The ultra-compact bird-borne S-band transceiver made of Texas Instrument Inc. CC2500 for packet communication can choose a transmission speed from 1200 bps to 500kbps, and can choose a modulation-technique from 2FSK, GFSK, MSK, OOK. We designed and fabricated the transceiver for the bird-to-bird communications and the bird-to-centre communications. And then we sought the optimal parameter for both communications by using the evaluation experiment As a result, it was clear that OOK is good one and that it could improve C/N compared with 2FSK.

Reference

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